Review of "Analogue experiments on releasing and restraining bends and their application to the study of the Barents Shear Margin"

Summary:

This paper uses analog modeling to address the structural and basinal evolution of the Barents shear margin. The article has the scientifically significant potential to help understand both this topic and contribute to discussions on basin inversion and how plate margins evolve through varying deformation modes.

The manuscript begins with a regional background and description of locations of interest and their major structures. This section provides important information; however, grammatical mistakes and missing elements in Figure 1 detract from its utility.

The following section enters a detailed description of the models and structural observations made in the models. The models follow a velocity discontinuity approach using a margin cut to match the Barents shear margin. This section is generally okay, yet the authors could include additional details about the methodology and model scaling. For example, dimensional considerations of each layer, specifically the dimensions of the silicone strip and its role in nucleating deformation, are only briefly mentioned. Furthermore, analyses of these models comprise only visual analysis of photos taken during the evolution and cross-sectional analysis. These experiments are lacking in that they could have used more state-of-the-art analysis techniques like particle image velocimetry to better understand the fault kinematics and deformation partitioning throughout the model's development. The figures in this section also seem out of place/mixed up, and poorly labeled. Yet, ultimately, the experiments overall reproduced the major basins and structures seen in the Barents shear margin, allowing the authors to conclude that the sequence of phases supports the established tectonic models.

My main reservation is that in the manuscript, comparison and discussion of the model and natural case are largely descriptive and sometimes repeat things already established in the introduction. There is little discussion about what we can learn about the process. What is the role of natural conditions that cannot be included in the model? For example, the thermal structure of the volcanic province. What explains the differences between the models and nature? What are the more significant takeaways? How does basins stratigraphy link to margin evolution? That said, the authors explain some critical insights, including strain localization and the changing geometry of marginal faults in the Vestbakken Volcanic province, the timing of basin linkage, and constraints on the shortening mechanisms of the margin parallel basin systems. If the authors included more interpretations of the relationship between model results and the evolution of the Barents margin, the paper would be much more substantial. And, if they used PIV, certainly more could be learned.

One glaring issue with this paper is the significant spelling and grammar mistakes. These strongly detract from how effectively the material is communicated, including issues with figures that make them challenging to critique and understand (missing scale bars, missing labels, incorrect captions).

Specific comments:

Lines 148 – 151: This paper helps understand multistage sheared passive margins. By using analog models, you can investigate the stages of deformation on the way to the present-day setting. However, there do not seem to be any specific questions that the authors are trying to answer. What about the structural complexity? What makes it complex? How well do we understand these

margins at present? Complexity is a blanket term. What exactly don't we know? What are the implications of this work, both specific to the Barents margin and from a process-oriented perspective? The language the authors use is sometimes too vague: set into a dynamic context, complexity, structural elements? These words help frame the main issues, but the authors could expand the ideas to more specific scientific challenges.

Figure 1: Panel B does not include many labels in the caption. The locations of interest are difficult to find without prior knowledge of the area. What do the red dotted lines in this figure represent? What is the dashed line by 6? What do the numbers mean? The figure does not stand alone.

Line 163: It is hard to know where these elements are displayed if there are no labels in Figure 1B

Line 165: This is somewhat confusing language. Preceded by? Did this zone come before, or did the term used to be the *De Geer Zone*?

Lines 167, 193, 219, and many other places: structuring is not a common word and seems strange here.

Line 175: This could be moved to the Senja Shear Margin paragraph.

Line 188: What is meant by "may approach 18 – 20 km"? Are there poor constraints? Or does it only approach that in some locations?

Line 208 – 219: Personally, it makes more sense to describe the Sørvestsnaget basin last since the description includes structural elements that are not introduced until later.

Line 263: Did this volcanic activity affect the crustal evolution of the Barents sea? Did thermal weakening play any modifying role in strain partitioning? Perhaps, this can explain some differences between nature and the models.

Line 273: This comes off as a random or fragmented idea. What is this sentence referring to? The secondary faults? What is the imprint? I think this sentence can be deleted.

Line 294: The characteristics of tectonic inversion? What characteristics? This sentence is too general. Are you referring to lines 295 – 297? Why not say something more specific like: " The axial traces of folds and the structural grain of thick-skinned master faults are roughly parallel. This observation suggests that the position and orientation of folds were influenced by the preexisting structural fabric created by thick-skinned master faulting."

Lines 330 – 331: This is a bit ambiguous. What are the specific limitations? Is there poor exposure or not enough data? Is it hard to comprehend or impossible? I suppose you are saying that you cannot go back in time and see all of this. Is it not more than geometries but variable kinematics and dynamics through time?

Figure 2: Please define the PSE and SPE acronyms here. That would make things easier for the reader than combing the text to find what they mean. Additionally, I think this figure would benefit from more labels, like the snake head geometries.

Line 382: Is the length scaling of the boundary cut here in agreement with the total displacement and rate? i.e., do the convergence rates and amounts scale as well?

Line 389: How was the crust tapered? How was the taper angle chosen? Randomly? Or related to what is observed?

Figure 3: What do the colors represent in panel B? A legend would be helpful here. Is the silicon layer just a strip over the VD?

Lines 405 – 413: These are results and would perhaps be better placed in that section.

Line 425: It would be worth mentioning how the authors chose the obliquity angle. Is there field data that suggests this is on the order of what happened in nature? Trans-pression/-tension experiments indicate that this angle plays a significant role in the structural evolution of the system, so it is alarming that this is glossed over.

Line 429: Apologies because I have never used a sieve in analog models. But, I am unsure what or how sieving works to fill basins or what is being done. Could you explain this more?

Lines 443 – 447: How were the dimensions of the silicon strip chosen? Width, thickness? Was this by trial and error? From my experience with similar experiments, the dimensions of the strip can strongly affect the nucleation and propagation of deformation.

Line 467 – 468: Why did the authors not use PIV in this study? PIV is an excellent and easy-to-use tool for studying analog fault kinematics. The photos taken would work easily with PIV software and be especially useful with marker particles. This technique would greatly expand the dataset and provide much more insight into the behavior of the faults throughout the model evolution.

Lines 499 – 501: This sentence seems unnecessary. Clearly, cross sections must be cut to understand folds and faults in detail.

Line 504: I appreciate the use of non-genetic terminology. However, I think the authors should define PSE, SPSE, and EPS acronyms together.

Line 534: en echelon what? Folds? Faults?

Lines 536, 538: I understand that R, R', P, and Y have been used extensively in the literature for wrench systems. However, it does not hurt to add a sentence or two to remind the reader what their orientations are, at least, especially since the terminology is not always consistent. For example, Y-shears vs. R_1' shears. It just becomes confusing.

Figure 5: This figure is nice and reasonably well-labeled. Still, it should include all the major structural elements described here. There is a measuring tape here, but it cannot be seen due to the low resolution of the pictures.

Figure 6: This figure is a bit too bare to be useful. Where are the labels? Which phase is which? The faults could be labeled too. At the least, it should be consistent with figure 5. There is a measuring tape here, but it cannot be seen due to the low resolution of the pictures.

Lines 592 – 594: Can this be expanded? So, adding the sand forced the structures in the system? Perhaps, this strongly impacts the subsequent model evolution. What if no sand is added? What if less sand is added? What if sand is added syntectonically?

Figure 7: What do the colors mean here?

Line 650 – 651: It would be easier to see these Y shears if labeled in the figures.

Line 652 – 654: Would they? Is this an interpretation or a fact? Is there a reference that can be included here or more explanation?

Line 657 – 659: Again, how were the dimensions of the silicone calibrated?

Figures 9 & 10: I think the captions have been accidentally swapped.

Line 694: Very quickly? In what frame of reference is this fast? Relative to other experiments? Is it scaled to nature?

Line 713: Why was this choice made?

Line 744: What is a "shifting stress relation"?

Lines 745 – 756: I appreciate a summary here and there, but this is quite repetitive.

Line 762 – 763: These "complexities" regarding process or mechanics are incredibly vague. Could this be expanded to be more specific?

Lines 777 – 782: This is very descriptive, but there is little discussion of interpreting these structures in the context of the Barents shear margin. Except at the end, where it is made clear that none of these are seen. Why is this? Perhaps, that in itself provides a clue to the margin's evolution. Maybe this could be investigated more.

Lines 785 – 786: This seems a bit redundant. Of course, oblique opening would occur during oblique extension, right?

Lines 790 – 792: Here is another example where there might be something more to say about the Barents margin, but the discussion is cut short. Why was there no superior basin system? Was there not enough extension? The two paragraphs here just say, “we observed something in the model, but we don’t actually see it in nature.”

Lines 798 – 800: It could be nice to write that on a label showing the segments. Perhaps, written in italics or something so that the reader can look at the fig and completely understand what it represents.

Line 827: What about the complex fold systems? It is still unclear what questions are trying to be answered in this study except to simulate the margin and redescribe the observed structures. There is much more to be said about the structural and basinal history of the margin evolution.

Line 844: What is an EPS-2 structure? Can we see this somewhere in the models (labeled figures)?

Figure 10: It is clear that the captions are mixed up. However, it could be nice here to label the crocodile structures.

Figure 11: Where are the yellow arrows? No scale bar!?

Lines 884 – 887: This paragraph seems fragmented.

Lines 887 – 890: This is a nice, clear, well-described insight provided by the experiments that helps understand the natural system. I think including more discussions like this would make this a stronger manuscript.

Figure 12: Missing scale bar. Nonetheless, this figure nicely highlights things that can be learned from the models about the system's kinematics.

Lines 932 – 943: Another excellent example of where the authors have nicely used the experimental results to provide valuable insights into nature.

Line 972 – 973: What is this new light? Can this be explained more?

Lines 975 – 986: One of the paper's main takeaways: the system's evolution was confirmed by the experimental simulation of deformation events. In itself, this is nice!

Line 990: Were you able to confirm whether the boundary was likely oblique or not? I think it could be emphasized how the obliquity changed the model results and what this means in nature.

Technical comments:

Line 185: isolate → isolated

Line 190: Subsequently → subsequent

Line 198: coincides → coincide

Line 201: A classical setting for transpression would be better worded as a “type setting” or “well-described setting.”

Line 217: “likely strongly” is poor grammar.

Line 294-295: The grammar in this sentence should be corrected.

Line 308: strikes → strike

Line 323: tothe → to the

Line 387: Whereas ~~the~~ those

Line 480: A series of totally nine?? This paper should be better proofread for English fluency and spelling. → “Nine total experiments” or a “series of nine experiments”.
Line 528: faultsin → faults in

Line 544: cm → cms

Line 545: steeped → steepened

Line 664: ~~utilized~~

Line 716: faults., → faults,

Line 773 – 774: Poor grammar makes the sentence unintelligible.

Line 777: Poor grammar
Lines 814 – 819: Sentence grammar makes it unreadable.

Lines 923 – 927: This sentence is tough to understand.

Line 954: my → by